[0019] FIG. 4 is a block diagram of an example system that includes an intra-ocular device in wireless communication with an external reader.

[0020] FIG. 5A is a top view of an example intra-ocular device.

[0021] FIG. 5B is side cross-section view of part of the example intra-ocular device shown in FIG. 5A.

[0022] FIG. 5C is side cross-section view of elements of the example intra-ocular device shown in FIG. 5A.

[0023] FIG. 5D is a top view of the example intra-ocular device of FIG. 5A embedded within a polymeric material.

[0024] FIG. 5E is side cross-section view of the example intra-ocular device embedded within the polymeric material shown in FIG. 5D.

[0025] FIG. 5F is side cross-section view of the example intra-ocular device of FIG. 5A disposed within a lens capsule of an eye.

[0026] FIG. 6 is a flowchart of an example process.

DETAILED DESCRIPTION

[0027] In the following detailed description, reference is made to the accompanying figures, which form a part hereof. In the figures, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, figures, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

I. OVERVIEW

[0028] An intra-ocular device could be positioned within a lens capsule of an eye (following the removal of the natural lens from the lens capsule) to provide a means for focusing light from outside the eye onto the retina of the eye. Such an intra-ocular device could include an electronic lens that can be controlled to provide an optical power (e.g., a degree of focusing of light, such as may be measured in diopters) within a range of optical powers. The optical power of the electronic lens could be controlled to focus images of near and far objects alternatively over time. That is, the electronic lens could be controlled to have a first optical power during a first period of time to provide images of far objects (e.g., objects more than approximately 20 centimeters away from the eye) in focus on the retina of the eye, and the electronic lens could be controlled to have a second optical power greater than the first optical power during a second period of time to provide images of near objects (e.g., objects approximately 9 centimeters away from the eye) in focus on the retina of the eye.

[0029] Control of the optical power of the electronic lens could be related to accommodation forces applied to the intra-ocular device via the lens capsule. Such accommodation forces could be coupled to the intra-ocular device by a polymeric material configured to be in contact with the inside surface of the lens capsule. The intra-ocular device could be disposed within the polymeric material such that accommodation forces applied to the polymeric material (via the lens capsule) can be coupled to the intra-ocular device. The polymeric material could be configured to maintain the shape, volume, and/or structural integrity of the lens capsule after installation (e.g., after the formation of a rhexis (i.e., tear) in the lens capsule to allow removal of a natural lens and installation of the intra-ocular device and polymeric material). The optical power of the electronic lens could be controlled by the coupled accommodation forces directly (e.g., the coupled accommodation forces could deform the electronic lens or other elements of the intra-ocular device and/or polymeric material, causing a change in the optical power thereof) and/or indirectly (e.g., the coupled accommodation forces could be detected by an accommodation sensor of the intra-ocular device and the electronic lens could be electronically controlled based on the detected accommodation force). In examples wherein accommodation forces at least partially directly control the optical power of the intra-ocular device, a power requirement of the intra-ocular device could be reduced relative to examples wherein controlling the optical power of the intra-ocular device is effected primarily by active electronic control of the electronic lens.

[0030] Coupling of forces between the intra-ocular device and the lens capsule could be achieved by forming and/or disposing a polymeric or other flexible, deformable material around the intra-ocular device and in contact with the inner surface of the lens capsule. Such a material formed and/or disposed to be in contact with the lens capsule could couple forces from the lens capsule, through deformation of the material, to the intra-ocular device. Such coupled forces could act to deform all (i.e., the intra-ocular device could be wholly flexible) or part (i.e., the intra-ocular device could include one or more rigid elements) of the intra-ocular device. Such deformations could cause a change in the optical power of one or more optical elements of the intra-ocular device (e.g., by changing a geometry or a flexible electronic lens and/or some other type of flexible lens) and/or could be detected by the intra-ocular device (e.g., by an accommodation sensor) and used by electronics of the intra-ocular device to control the optical power of an electronic lens of the intra-ocular device.

[0031] Such a force-coupling material could be formed by depositing a fluid into the lens capsule (following removal of the lens from the lens capsule), positioning the intra-ocular device within the fluid in the lens capsule (e.g., aligned with an optical axis of the eye), and solidifying the fluid (e.g., by photopolymerization or some other process related to the composition of the fluid). A material formed through such a process could be in intimate contact with the inner surface of the lens capsule, allowing coupling of forces from the lens capsule into the polymeric material and further into any contents of the material (e.g., into the intra-ocular device). Positioning of the intra-ocular device, fluid, material, or other elements could be accomplished by using a laser or other surgical instrument to form a hole in the anterior surface of the lens capsule. The existing natural lens could be removed by fragmentation (e.g., using ultrasonic vibrations) and removed (e.g., via suction in concert with a matched addition of fluids to maintain the volume and shape of the lens capsule).

[0032] The electronic lens could be configured in a variety of ways to enable electronic control of the optical power of the electronic lens. The electronic lens could include piezo elements, electro-wetting elements, liquid crystal elements and/or reservoirs, microfluidic elements and/or reservoirs, or other electronic actuators configured to change a geometry (e.g., a shape, a thickness, a curvature) of the electronic lens based on an electric signal applied to the electronic lens.